Extracting Self-Direction Strategies and Representing Practices in GOAL System

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ABSTRACT: To enable students to engage in lifelong learning, it would require developing self-direction skills (SDS). The use of technology in education is common, however, the available software still offers poor support from a self-direction point of view. From the theories of self-directed learning (SDL) and evidence-based practice (EBP), we proposed a framework to track self-directed actions and represent strategies of practice by the learner. This framework is one of main components of the GOAL (Goal Oriented Active Learner) system. The GOAL system is built to support for acquisition of SDS in the context of learning and health. In this paper we describe how learner interactions in the GOAL system are captured as eXperience API statements and later visualized to enable learners reflect on their strategies.

Keywords: Self-direction skills, evidence-based practice, learning analytics, DAPER model, GOAL system

1 INTRODUCTION

With the growing trend of preparing students for lifelong learning, the theory of self-directed learning (SDL) has been increasingly applied in the context of higher education. Being self-directed would help students to prepare them for success in their future careers, and enables them to engage in lifelong learning. Since it's a cognitively and behaviorally complex task during executing SDL, the ongoing diagnosis of learners in underdeveloped skills and instructional design of environment are essential.

We developed the GOAL (Goal Oriented Active Learner) system, where learner engage with their own data from learning and physical activities context to foster their skills of being self-directed (Majumdar et al., 2018). The idea is to support students for acquisition of self-direction skills (SDS) through everyday activities. Since the learning logs and health records could be automatically integrated into our support system, students are given more opportunities to engage in self-direction.

In this paper, we propose a framework to address the challenge of tracking self-direction practices of the learners. We capture the student actions as eXperience API statements. Utilizing those action statements, first we extract strategies of self-directedness. Then students' self-directedness practices could be represented in a simple format to support self-assessment and self-reflection.

2 RELATED WORK

2.1 Self-Direction Models

SDL is primarily studied in the context of adult education and covers the following processes: learning needs or learning motivation, learning resources, learning goals, learning plans and activities, learning evaluation, and communication skills.

Three main models have been proposed to study SDL: Candy's four-dimensional model (Candy, 1991), Brockett and Hiemstra's personal responsibility orientation model (Brockett & Hiemstra, 1991) and Garrison's three-dimensional model (Garrison, 1997). Candy (1991) concluded that SDL encompasses four dimensions: personal autonomy, self-management, learner-control, and autodidaxy. Brockett and Hiemstra (1991) provided a rationale for two primary orientations in developing an understanding of SDL: process and goal. Garrison's model of SDL includes three dimensions interacting with each other: self-management, self-monitoring, and motivation.

For our work, we proposed a process model, DAPER (Majumdar et al., 2018) which synthesizes the SDL model for data driven activities. The initial phase of data collection which gives learners the initiative, followed by four key phases (data analysis, goal setting and planning, executing monitoring, reflection). Section 3.1 presents the details on those five phases of the model.

2.2 Measuring Self-Direction

Mostly in the context of learning, learners rely on their own memory and notes to define their goals and plans, and then monitor and evaluate their own progress and performance. The researchers commonly assess learners' SDS using self-reported questionnaires, like PRO-SDLS (Stockdale & Brockett, 2011), SRSSDL (Williamson, 2007) or SDLI (Cheng et al., 2010). While these instruments provide a picture of each learner's skills at a certain moment in time, they do not continuously track learner's skills. Also, these instruments are intrusive and time consuming.

However, the assessments could be supported through tracking interactions with software, especially in online learning environment (Li et al., 2018). The key interactions related to metacognition of self-direction should be extracted, like goal setting, planning, reflection, etc. Moreover, since a wide variety of self-direction interactions could be recognized, the definition of self-direction actions and strategies should be identified.

2.3 Evidence-Based Practice

In epistemology, evidence is that which serves to confirm or disconfirm a hypothesis (claim, belief, theory; Achinstein, 2001). It can perform a support function, including all sorts of data, facts, and personal experiences. Evidence-based practice (EBP) involves the use of the best available evidence to bring about desirable outcomes, or conversely, to prevent undesirable outcomes (Kvernbekk,

2016). Moving toward more EBP has the potential to improve the quality of learning, especially the acquisition of SDS.

Because of the complexity in the self-direction cycle, more high level data need to be provided for learners. The learners need reliable, revealing and relevant data that support decision-making. To support it, the five phases of DAPER model, activity model, strategies extraction, and practice representation are described in the following section. Previous studies of self-direction and self-regulation has highlighted learner agency regarding how they learn and the superiority of autonomous motivation for learning (Stockdale & Brockett, 2011; Greene & Azevedo, 2007). We follow that paradigm and let students choose their own goal and direct their own plan.

3 MODELING PROCESS AND ACTIVITY OF SDS

3.1 DAPER Model

DAPER model is a five-phase process model to conceptualize data driven self-direction skill execution and acquisition (Majumdar et al., 2018). Figure 1 shows the DAPER model and its five phases.

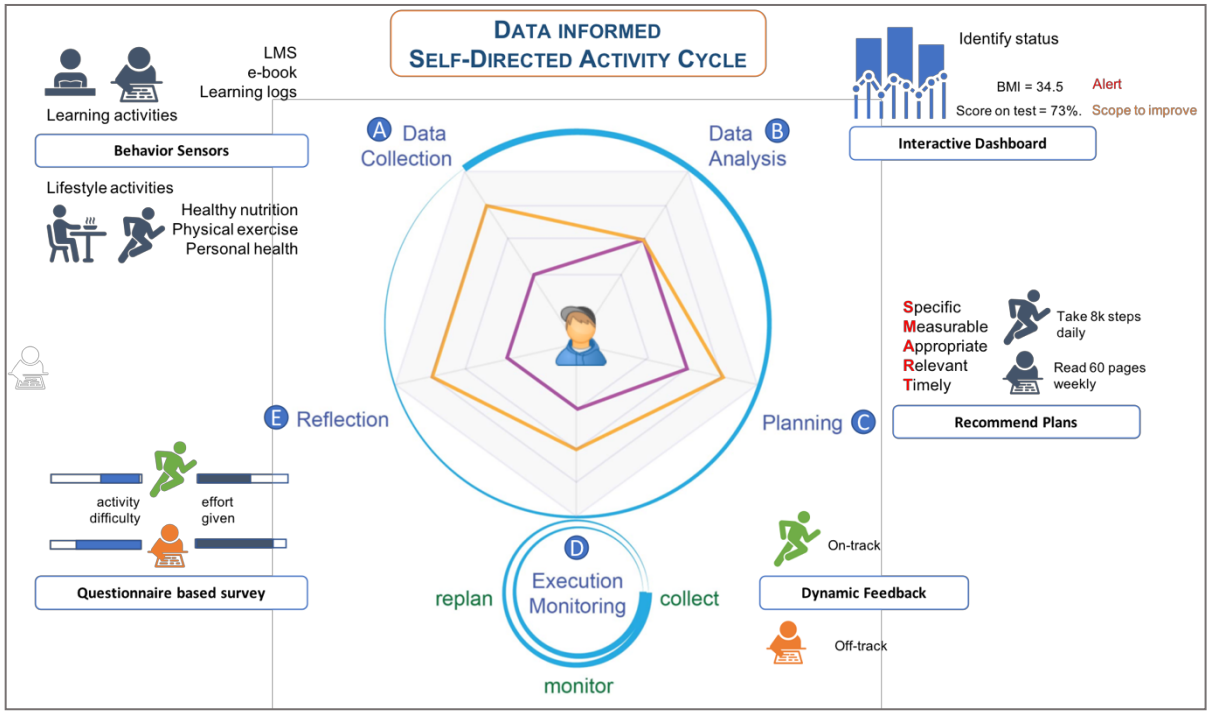

Figure 1: DAPER model and its five phases of SDS execution and acquisition (Majumdar et.al. 2018)

A. Data Collection. Most of activity data will be automatically collected from activity sensors. For the health activities, the raw data is from smartphones and wearable devices. For the learning activities, the raw data is collected from an e-book system BookRoll and an e-learning system Moodle. Also, learners can add their records manually if the records were not automatically collected, revise their records and delete certain records.

B. Data Analysis. The trend of one activity will be showed by chart graph, and the average value of one activity will be compared with the standard level or the average value of group. Based on the trend and compared results, the status of each activity will be easily identified.

C. Goal setting and Planning. After being aware of their status of each activity, learner set goals regarding any activities whose data was analyzed. The goals could be specific with a target value and expected date, or not specific just with a description. Under one goal, multiple plans could be created. The plans are with different frequencies, target values and duration.

D. Execution monitoring. The progress of each plan will be shown by chart graph since the activity data will be continuously collected and be compared with the target value. For example, in the health scenario, learners may monitor their heart rate during a specific physical exercise. In the learning scenario, learners might monitor the completion of their course content before an upcoming assessment. This phase often includes multiple cycles of other phases, including data collection, analysis, re-planning, refection.

E. Reflection. During the process of self-directed, learners could write daily reflection journal for their goals or plans with self-rated items and notes. The self-rated items include the evaluation of task performance and their efforts given for the chosen task. The note form is a single text field which is organized by learners. The information in the notes could be current problems, specific strategies, or further actions.

GOAL system is based on the described DAPER model. Learners can build their personal goals and continuously improve them in the context of learning and health. The phases of DAPER model are weakly sequenced so currently the learner can openly navigate in the GOAL system and access functions of any phase.

3.2 Activity Model

Activity model provides a context of self-direction in the Goal system. It has two elements: *Activity* and *Milestone*.

The *Activity* is learning logs or health records automatically collected from activity sensors, such as smartphones. Learning logs are tracked by the e-book and e-learning system. They contain digitized reading logs, status of course assignments, and answers of quizzes. The health records are collected through Apple Health application or Google Fit platform. They include steps taken, runs, walks, workouts, biking, sleep, weight, heart rate, and food. For example, an *Activity* could be reading 50 pages or running 3 kilometers.

The *Milestone* is an accumulated value from the *Activity*. It's as an indicator of the activity achievement. A *Milestone* could be the first try, completed 25%, completed 50%, or completed 100%.

4 FRAMWORK FOR EXTRACTING AND REPRESENTING SELF-DIRECTED PRACTICES

First, we extract strategies from interactions between learners and the GOAL system and activity logs. The definition of strategies is from the five phases of DAPER model. Next, we integrate these strategies into practices of self-direction and represent the practices to support self-assessment and self-evaluation for each individual users.

4.1 Extracting Strategies

Following xAPI structure we define strategies of self-direction. Table 1 shows a list of definition of self-direction strategies. The self-direction strategies are from five phases of DAPER model. They consist of activity log management, activity log analysis, goal management, planning, self-monitoring, and self-evaluation. Each strategy includes multiple actions. An action is defined by the verbs and the objects in the GOAL system. For instance, *John created a plan "Running at weekdays"* is an action which contains a verb, *created*, and an object, *a plan "Running at weekdays"*.

Table 1: Definition of self-direction strategies

DAPER Phase	*Strategy*	*Verb*	*Object*	*Example*
Data collection	Activity log management	*added* *edited* *deleted*	activity log	John added an e-book reading log
Data analysis	Activity log analysis	*checked*	activity log	John checked the activity "Running"
Goal setting and planning	Goal management	*created* *edited* *deleted* *achieved* *discarded*	goal	John edited the goal "Get A+ Grade" with a new description "Complete all reports"
	Planning	*created* *edited* *deleted*	plan	John created a plan "Running at weekdays"
Executing monitoring	self-monitoring	*checked*	plan	John checked "Plan 3" at 2:00 pm
Reflection	self-evaluation	*noted* *scored*	goal plan	John scored the effort to the plan "Running at weekdays" with "Much"

4.2 Utilizing Strategies to Represent Practice

After extracting self-direction strategies, the practice will be generated and represented for learners. It's a key component to support decision-making when learners reflect their practices or identify obstacles.

The components of practice are *Activity*, *Milestone*, *Decision* and *Achievement*. The *Activity* and *Milestone* are from the activity model. The *Decision* means key interactions between learners and

the GOAL system. It's related to manage goals and plans: created a goal, edited a goal, deleted a goal, created a plan, edited a plan, deleted a plan, noted a goal, scored a goal, noted a plan, scored a plan. The *Achievement* means that a goal has been achieved or discarded.

We chose a tree and a timeline structure to represent practices. An example of practice representation with an editable tree and a visual timeline is given in Figure 3. The tree of practice has three columns: activity & action, date and description. The activity & action column contains *Decision*, *Milestone* and *Activity*. As noted before, the name of *Decision* is generated from the action between learners and the GOAL system. The default descriptions are from inputs when learners manage goals or plans. For instance, the description of "Created a goal" is the input description of the new goal, the description of "Edited a plan" is the target value and frequency value of the updated plan. Moreover, each branch of practice tree could be edited by learners.

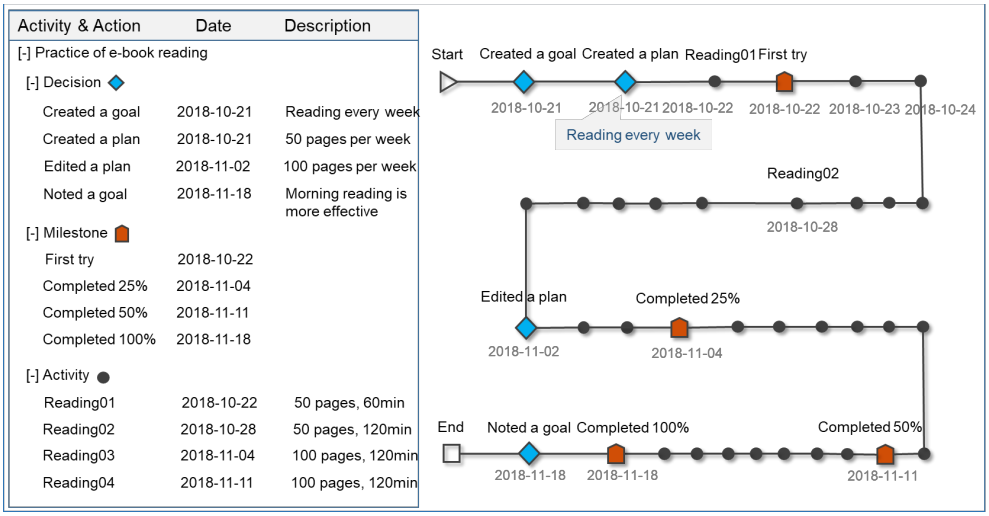

Figure 3: An example of practice representation with an editable tree and a visual timeline

We also generated a timeline to represent practices. The timeline of practice is from the left tree data but with a user-friendly visual format. It also contains *Decision*, *Milestone* and *Activity*, which are shown with blue diamond icons, red arrow icons and black dot icons, respectively. It also has start and end date of one goal. It will be generated when one goal was achieved or discarded. The description of one element will be shown when the learner tries to click it. For example, learner will see "Reading every week" when click the *Decision* element, *Created a plan*.

Thus, our developed framework (shown in Figure 2) contains two steps: self-direction strategy extraction and self-direction practice representation. The basic structure of strategy combines information from the DAPER model and the activity model. Practice is represented for each individual based on their own activity trace data and GOAL system interaction data.

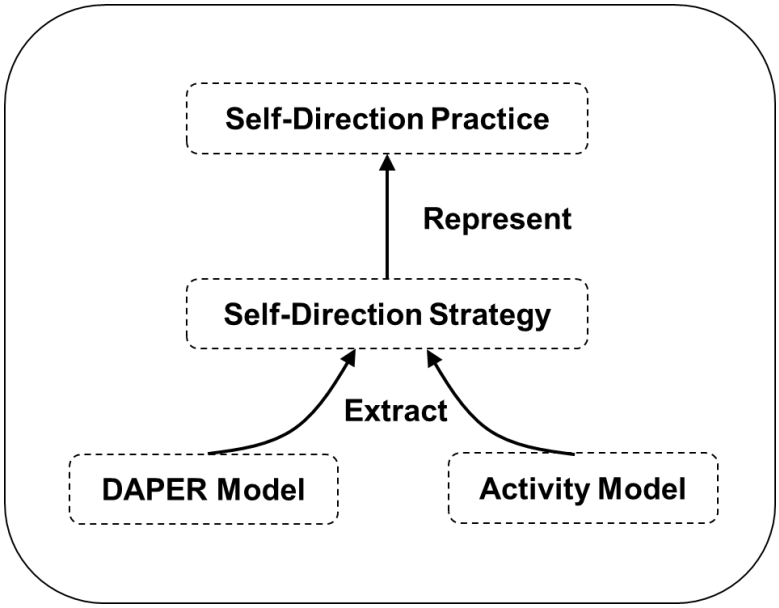

Figure 2: Framework for extracting and representing self-directed practices

5 DISCUSSION

5.1 Measurement of Self-Direction

What information should be extracted during self-direction process? In our work we use two kinds of trace data to answer the question: activity trace data, from the activity logs in the context of self-direction and interaction trace data, from the interaction logs in the GOAL system.

Since the rapid development of smartphones and wearable devices, tracking fine-grained, time-stamped data from learning and health activities is more common (Ogata et al., 2017; Case et al., 2015; Hekler et al., 2015). In contrast to self-report data, trace data is immediately collected within actual environment and could not be degraded the accuracy and completeness of learners' recall, perceptions and interpretations about how they learn.

The versatility and openness of xAPI makes us to define a wide and comprehensive selection of self-direction actions, directly related to the selection of the most relevant self-direction strategies (Manso-Vázquez et al., 2018). We start a simple definition of strategies from actions and activities since it could be part of complex strategies. For instance, a complex strategy called goal-oriented planning, could be formed by two simple strategies: goal management, planning. The simple definition is suitable to represent the complexity of self-direction strategies.

Combine activity trace data and interaction trace data, not only activity status but also strategy selection could be measured. These simple but important activities and interactions can be the foundation for learning analytics and evidence-based analytics in the context of data-driven self-directed activities.

5.2 Feedback for Supporting SDS Development

What information should be presented to support SDS development? We proposed a practice-based feedback to facilitate the selection of strategies.

Feedback is a powerful influence on learning, especially on SDL. It's not easy for novice SDL learners to select, monitor and evaluate their strategies independently. We offer learners feedback with practice trees and practice timelines. The *Decision* and *Milestone* on them are strategic level information, which contain a format of knowledge. Other format of feedback could also be considered based on self-direction strategies, such as strategies time distribution, strategies preference with a radar graph and so on.

6 CONCLUSION

This paper proposed a framework which could extract self-direction strategies and represent practices with editable trees and visual timelines. The actions and activities of self-direction process are captured to the strategies as eXperience API statements and then those strategies are presented with practice information. The framework is built on the DAPER model with five phases of self-direction process. The activity data and interaction data are tracked and therefore important activities and interactions related to strategies could be represented, like goal management, planning, self-evaluation. The framework provides reliable, revealing and relevant data and practice-based representation that support making valid inferences, which is essential for acquiring and promoting SDS.

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REFERENCES

Achinstein, P. (2001). *The book of evidence*. Oxford: Oxford University Press.

Bjorklund, D. F., Miller, P. H., Coyle, T. R., & Slawinski, J. L. (1997). Instructing children to use memory strategies: Evidence of utilization deficiencies in memory training studies. *Developmental Review, 17*(4), 411-441.

Brockett, R. G., & Hiemstra, R. (2018). *Self-direction in adult learning: Perspectives on theory, research and practice*. New York: Routledge.

Candy, P. C. (1991). *Self-Direction for Lifelong Learning. A Comprehensive Guide to Theory and Practice.* Jossey-Bass, 350 Sansome Street, San Francisco, CA 94104-1310.

Case, M. A., Burwick, H. A., Volpp, K. G., & Patel, M. S. (2015). Accuracy of smartphone applications and wearable devices for tracking physical activity data. *Jama, 313*(6), 625-626.

Cheng, S. F., Kuo, C. L., Lin, K. C., & Lee-Hsieh, J. (2010). Development and preliminary testing of a self-rating instrument to measure self-directed learning ability of nursing students. *International journal of nursing studies, 47*(9), 1152-1158.

Davies, P. (1999). What is evidence-based education?. *British journal of educational studies, 47*(2), 108-121.

Garrison, D. R. (1997). Self-directed learning: Toward a comprehensive model. *Adult education quarterly, 48*(1), 18-33.

Greene, J. A., & Azvedo, R. (2007). A theoretical review of Winne and Hadwin's model of self-regulated learning: New perspectives and directions. *Review of Educational Research, 77*(3), 54–372.

Hadwin, A., Oshige, M., Miller, M., & Wild, P. (2009, July). Examining student and instructor task perceptions in a complex engineering design task. In *international conference on innovation and practices in engineering design and engineering education. McMaster University, Hamilton, ON, Canada*.

Hekler, E. B., Buman, M. P., Grieco, L., Rosenberger, M., Winter, S. J., Haskell, W., & King, A. C. (2015). Validation of physical activity tracking via android smartphones compared to ActiGraph accelerometer: laboratory-based and free-living validation studies. *JMIR mHealth and uHealth, 3*(2), e36.

Kvernbekk, T. (2016). *Evidence-based practice in education: Functions of evidence and causal presuppositions*. London: Routledge.

Li, H., Flanagan, B., Konomi, S. I., & Ogata, H. (2018). Measuring Behaviors and Identifying Indicators of Self-Regulation in Computer-Assisted Language Learning Courses. *Research and Practice in Technology Enhanced Learning, 13*(1), 19.

Majumdar R., Yang Y.Y., Li H., Akçapınar G., Flanagan B., & Ogata H. (2018) GOAL: A System to Support Learner's Acquisition of Self Direction Skills, *26th ICCE*, Manila, Philippines, Nov 2018

Manso-Vázquez, M., Caeiro-Rodríguez, M., & Llamas-Nistal, M. (2018). An xAPI Application Profile to Monitor Self-Regulated Learning Strategies. *IEEE Access, 6*, 42467-42481.

Ogata, H., Oi, M., Mohri, K., Okubo, F., Shimada, A., Yamada, M., & Hirokawa, S. (2017) Learning Analytics for E-Book- Based Educational Big Data in Higher Education. In *Smart Sensors at the IoT Frontier* (pp. 327-350). Springer, Cham.

Oppezzo, M., & Schwartz, D. L. (2014). Give your ideas some legs: The positive effect of walking on creative thinking. *Journal of experimental psychology: learning, memory, and cognition, 40*(4), 1142.

Saks, K., & Leijen, Ä. (2014). Distinguishing self-directed and self-regulated learning and measuring them in the e-learning context. *Procedia-Social and Behavioral Sciences, 112*, 190-198.

Stockdale, S. L., & Brockett, R. G. (2011). Development of the PRO-SDLS: A measure of self-direction in learning based on the personal responsibility orientation model. *Adult Education Quarterly, 61*(2), 161-180.

Williamson, S. N. (2007). Development of a self-rating scale of self-directed learning. *Nurse researcher, 14*(2).

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American educational research journal, 45*(1), 166–183.